NIH/NSF Visualization Research Challenges Workshop
Position Statement

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I am writing this position statement from the perspective of a heavy user of visualization tools, not as a researcher in the area. My primary research area, medical imaging, is filled with opportunities for creative use of visualization tools, and several areas are begging for novel developments. I expand briefly on three areas.

Multiparametric, vector, and tensor data. It is commonplace for the human body to be imaged using multiple imaging modalities such as MRI, CT, and PET. MRI itself is capable of generating many images comprising different contrasts from disparate tissue properties. It is becoming commonplace to image properties that are intrinsically vectors or tensors, as well. Imaging flow vectors is most common, but it is also possible to image strain and diffusion tensors using MRI and other modalities. Orientation-dependent properties of tissues that cannot be characterized by tensors, but require spherical harmonics or other orientation characterizations, are also being imaged.

Visualizing these data typically requires source-dependent knowledge. A pathline may be useful for flow vectors, but is inappropriate for principle strains, for example. Despite a wide variety of interesting approaches, it is still difficult to generate useful and meaningful pictures of this higher-order data that can provide a basis for measurement and discovery using these data.

Quantitative Visualization. While medical diagnoses are often made by simply looking at medical images, it is becoming more common in the digital imaging world of a modern radiology department to ask for quantitative measures within the data being observed. Simple tools such as linear distances and region-of-interest volumes are not enough, and even these are too often guided by manual delineation, which is typically inaccurate and user-dependent. There is a need to improve the suite of possibilities for measuring geometric and intensity properties of observed objects. Interaction with the data to yield volume measurements on regions-of interest, to provide the means to readily delineate and measure properties of patches, curves, and geodesics on surfaces is are needed. The automatic and reliable segmentation of structures both for visualization and measurement needs to be improved. Furthermore, these capabilities need to be coupled to the real-time acquisition and manipulation of source images for application in interventional medicine.

Longitudinal and Cross-sectional data. The detection of differences – e.g., between an individual and the average population, in an individual from one year to the next, or in a time series depicting an evolving biological process – is becoming increasingly important in medical science and clinical medicine, particularly in neuroscience. The ability to visualize these large collections of 3D (or 3D + time) data is critical to the characterization of normal human anatomy and physiology as well as to the determination of disease. Methods that require registration of these data to a common atlas should become a standard part of visualization tools and the segmentation of structures that is either at the core of registration or the result of atlas normalization should also be standard.

Techniques for the statistical analysis of longitudinal or cross-sectional data have been under rapid development over the past 15 years. Yet the visualization of statistical information has largely been relegated to the overlay of one statistic at a time on axial, coronal, and sagittal images. In pattern recognition, ones ability to visualize the rich collection of features and statistics by various projections onto visual planes is vitally important in the discovery process. Determining the relevant questions to ask is often the result of observations made from the display of statistics. Therefore, improving visualization methods will undoubtedly enhance discovery in medical science.